MACROINVERTEBRATE BIOASSESSMENT OF THE BOULDER RIVER, SWEETGRASS AND PARK COUNTIES, MONTANA

Report prepared for the

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INTRODUCTION

Aquatic macroinvertebrates are aptly applied to bioassessment since they are known to be important indicators of stream ecosystem health (Hynes 1970). Long lives, complex life cycles and limited mobility mean that there is ample time for the benthic community to respond to cumulative effects of environmental perturbations.

This report summarizes data collected in August 1999 from seven sites on the Boulder River, a tributary of the Yellowstone River in Sweetgrass and Park Counties, Montana. Macroinvertebrate assemblages were sampled by personnel of the Montana Department of Environmental Quality (Montana DEQ). A multimetric approach to bioassessment is applied in this study: this approach uses attributes of the benthic macroinvertebrate assemblage in an integrated way to measure biotic health. A stream with good biotic health is described as " ...a balanced, integrated, adaptive system having the full range of elements and processes that are expected in the region's natural environment..." (Karr and Chu 1999).

The additive multimetric approach designed by Plafkin et al. (1989) and adapted for use in the State of Montana has been defined as "... an array of measures or metrics that individually provide information on diverse biological attributes, and when integrated, provide an overall indication of biological condition." (Barbour et al. 1995). Community attributes that can contribute meaningfully to interpretation of benthic data include assemblage structure, sensitivity of community members to stress or pollution, and functional traits. Each metric component contributes an independent measure of the biotic integrity of a stream site; combining the components into a total score reduces variance and increases precision of the assessment (Fore et al. 1995). Effectiveness of the integrated metrics depends on the applicability of the underlying model, which rests on a foundation of three essential elements (Bollman 1998). The first of these is an appropriate stratification or classification of stream sites, typically, by ecoregion. Second, metrics must be selected based upon their ability to accurately express biological condition. Third, an adequate assessment of habitat conditions at each site to be studied is needed to assist in the interpretation of metric outcomes.

Implicit in the multimetric method and its associated habitat assessment is an assumption of correlative relationships between habitat parameters and the biotic metrics, in the absence of water quality impairment. These relationships may vary regionally, requiring an examination of habitat assessment elements and biotic metrics and a test of the presumed relationship between them. Bollman (1998) has recently studied the assemblages of the Montana Valleys and Foothill Prairies ecoregion, and has recommended a battery of metrics specific to that ecoregion, which has been shown to be sensitive to impairment, related to habitat assessment parameters and consistent over replicated samples.

Habitat assessment enhances the interpretation of biological data (Barbour and Stribling 1991), because there is generally a direct response of the biological community to habitat degradation in the absence of water quality impairment. If biotic health appears more damaged than the habitat quality would predict, water pollution by metals, other toxicants, high water temperatures, or high levels of organic and/or nutrient pollution might be suspected. On the other hand, an "artificial" elevation of biotic condition in the presence of habitat degradation may be due to the paradoxical effect of mild nutrient or organic enrichment in an oligotrophic setting.

METHODS

Aquatic macroinvertebrates were sampled by Montana DEQ personnel in August, 1999. Seven sites on the mainstem of the Boulder River were sampled. Sites are described in Table 1. The sampling method employed was that recommended in the Montana Department of Environmental Quality (DEQ) Standard Operating Procedures for Macroinvertebrate Sampling (Bukantis 1998). In addition to macroinvertebrate sample collection, habitat quality was visually evaluated at each site and reported by means of the habitat assessment protocols recommended by Bukantis (1998). Macroinvertebrate samples and associated habitat data were delivered to Rhithron Biological Associates, Missoula, Montana, for laboratory and data analyses.

Table 1. Sampling sites. Boulder River, August 1999. Sites are listed in an upstream-to-downstream direction.

Site number	Site description	GPS or UTM locations
1	Below Basin Creek	45° 13' 00" N / 110° 14' 59" W
2	Near Upper Aspen Campground	45° 27' 11" N / 110° 11' 27" W
3	Aller Ranch	45° 31' 28" N / 110° 13' 03" W
4	Hass Ranch	45° 34' 59" N / 110° 10' 57" W
5	Below the East Boulder River confluence	45° 37' 43" N / 110° 07' 20" W
6	McGuane Ranch	45° 46' 00" N / 109° 58' 48" W
7	Near the mouth	45° 50' 48" N / 109° 55' 66" W

In the laboratory, the Montana DEQ-recommended sorting method was used to obtain subsamples of 300 (+/- 30) organisms from each sample, when possible. Organisms were identified to the lowest possible taxonomic levels consistent with Montana DEQ protocols.

To assess macroinvertebrate communities in this study, a multimetric index developed in previous work for streams of the Montana Valleys and Foothill Prairies ecoregion (Bollman 1998) was used. Choice of an assessment protocol was problematic for this study, since the lower two sites sampled on the Boulder River lie within the Northwester Great Plains ecoregion (Omernik et al. 1997), the two upstream sites lie within the Middle Rockies ecoregion, and the three middle sites appear to lie within the Montana Valleys and Foothill Prairies (MVFP). A tested multimetric index exists only for the MVFP. This index was felt to be applicable to all sites in this study, based on taxonomic composition of the sampled assemblages and on the variety of MVFP sites utilized in the testing of the index (Bollman 1998).

Multimetric indices result in a single numeric score, which integrates the values of several individual indicators of biologic health. Each metric used in this index was tested for its response or sensitivity to varying degrees of human influence. Correlations have been demonstrated between the metrics and various symptoms of human-caused impairment as expressed in water quality parameters or instream, streambank and stream reach morphologic features. Metrics were screened so as to minimize variability over natural environmental gradients, such as site elevation or sampling season, which might confound interpretation of results (Bollman 1998). The multimetric index used in this

report incorporates multiple attributes of the sampled assemblage into an integrated score that accurately describes the benthic community of each site in terms of its biologic integrity. In addition to the metrics comprising the index, other metrics, which have been shown to be applicable to biomonitoring in other regions (Kleindl 1995, Patterson 1996, Rossano 1995) were used for descriptive interpretation of Ruby River results. These metrics include the number of "clinger" taxa, long-lived taxa richness, the percent of predatory organisms, and others. They are not included in the integrated bioassessment score, however, since their performance in the ecoregions of Montana is unknown. However, the relationship of these metrics to habitat conditions is intuitive and reasonable.

The six metrics comprising the bioassessment index used in this study were selected because both individually and as an integrated metric battery, they are robust at distinguishing impaired sites from relatively unimpaired sites (Bollman 1998). In addition, they are relevant to the kinds of impacts that are present in the Boulder River drainage. They have been demonstrated to be more variable with anthropogenic impairment than with natural environmental gradients (Bollman 1998). Each of the six metrics developed and tested for western Montana ecoregions is described below.

1. **Ephemeroptera (mayfly) taxa richness.** The number of mayfly taxa declines as water quality diminishes. Impairments to water quality which have been demonstrated to adversely affect the ability of mayflies to flourish include elevated water temperatures, heavy metal contamination, increased turbidity, low or high pH, elevated specific conductance and toxic chemicals. Few mayfly species are able to tolerate certain disturbances to instream habitat, such as excessive sediment deposition.
2. **Plecoptera (stonefly) taxa richness.** Stoneflies are particularly susceptible to impairments that affect a stream on a larger or reach-level scale, such as loss of riparian canopy, streambank instability, and alteration of morphological features such as pool frequency and function, riffle development and sinuosity. Just as all benthic organisms, they are also susceptible to smaller scale habitat loss, such as by sediment deposition, loss of interstitial spaces between substrate particles, or unstable substrate.
3. **Trichoptera (caddisfly) taxa richness.** Caddisfly taxa richness has been shown to decline when sediment deposition affects their habitat. In addition, the presence of certain case-building caddisflies can indicate good retention of woody debris and lack of scouring flow conditions.
4. **Number of sensitive taxa.** Sensitive taxa are generally the first to disappear as anthropogenic disturbances increase. The list of sensitive taxa used here includes organisms sensitive to a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others. Unimpaired streams of western Montana typically support at least four sensitive taxa (Bollman 1998).
5. **Percent filter feeders.** Filter-feeding organisms are a diverse group; they capture small particles of organic matter, or organically enriched sediment material, from the water column by means of a variety of adaptations, such as silken nets or hairy appendages. In forested montane streams, filterers are expected to occur in insignificant numbers. Their abundance increases when canopy cover is lost and

when water temperatures increase and the accompanying growth of filamentous algae occurs. Some filtering organisms, specifically the Arctopsychid caddisflies (*Arctopsyche* spp. and *Parapsyche* spp.) build silken nets with large mesh sizes that capture small organisms such as chironomids and early-instar mayflies. Hence, they are considered predators and in this study their abundance does not contribute to the percent filter feeders metric.

6. **Percent tolerant taxa.** Tolerant taxa are ubiquitous in stream sites, but when disturbance increases, their abundance increases proportionately. The list of taxa used here includes organisms tolerant of a wide range of disturbances, including warmer water temperatures, organic or nutrient pollution, toxic pollution, sediment deposition, substrate instability and others.

Scoring criteria for each of the six metrics are presented in Table 2. Metrics differ in their possible value ranges and also in the direction the values move as biological conditions change. For example, Ephemeroptera richness values may range from zero to ten taxa or higher. Larger values generally indicate favorable biotic conditions. On the other hand, the percent filterers metric may range from 0% to 100%; in this case, larger values are negative indicators of biotic health. To facilitate scoring, therefore, metric values were transformed into a single scale. The range of each metric has been divided into four parts and assigned a point score between zero and three. A score of three indicates a metric value similar to one characteristic of a non-impaired condition. A score of zero indicates strong deviation from non-impaired condition and suggests severe degradation of biotic health. Scores for each metric were summed to give an overall score, the total bioassessment score, for each site in each sampling event. These scores were expressed as the percent of the maximum possible score, which is 18 for this metric battery.

Table 2. Metrics and scoring criteria for bioassessment of streams of western Montana ecoregions (Bollman 1998).

	score			
metric	**3**	**2**	**1**	**0**
Ephemeroptera taxa richness	> 5	5 - 4	3 - 2	< 2
Plecoptera taxa richness	> 3	3 - 2	1	0
Trichoptera taxa richness	> 4	4 - 3	2	< 2
Sensitive taxa richness	> 3	3 - 2	1	0
Percent filterers	0 – 5	5.01 - 10	10.01 - 25	> 25
Percent tolerant taxa	0 – 5	5.01 - 10	10.01 - 35	> 35

The total bioassessment score for each site was expressed in terms of use-support. Criteria for use-support designations were developed by MT DEQ and are presented in Table 3a. Scores were also translated into impairment classifications according to criteria outlined in Table 3b.

In this report, certain other metrics were used as descriptors of the benthic community response to habitat or water quality but were not incorporated into the bioassessment metric battery, either because they have not yet been tested for reliability in streams of western Montana, or because results of such testing did not show them to be robust at

distinguishing impairment, or because they did not meet other requirements for inclusion in the metric battery. These metrics and their use in predicting the causes of impairment or in describing its effects on the biotic community are described below.

- The modified biotic index. This metric is an adaptation of the Hilsenhoff Biotic Index (HBI, Hilsenhoff 1987), which was originally designed to indicate organic enrichment of waters. Values of this metric are lowest in least impacted conditions. Taxa tolerant to saprobic conditions are also generally tolerant of warm water, fine sediment and heavy filamentous algae growth (Bollman, unpublished data). Loss of canopy cover is often a contributor to higher biotic index values. The taxa values used in this report are modified to reflect habitat and water quality conditions in Montana (Bukantis 1998). Ordination studies of the benthic fauna of Montana's foothill prairie streams showed that there is a correlation between modified biotic index values and water temperature, substrate embeddedness, and fine sediment (Bollman 1998). In a study of reference streams, the average value of the modified biotic index in least-impaired streams of western Montana was 2.5 (Wisseman 1992).
- Taxa richness. This metric is a simple count of the number of unique taxa present in a sample. Average taxa richness in samples from reference streams in western Montana was 28 (Wisseman 1992). Taxa richness is an expression of biodiversity, and generally decreases with degraded habitat or diminished water quality. However, taxa richness may show a paradoxical increase when mild nutrient enrichment occurs in previously oligotrophic waters, so this metric must be interpreted with caution.
- Percent shredders. Shredding organisms consume large particles of detritus such as leaves, needles and wood. Foothill and prairie streams with healthy riparian vegetation and sufficient instream structure to retain detritus will have large numbers of shredders. Often, this feeding group dominates the fauna of headwater streams. The abundance of shredders generally increases in the fall, when leaf and blade input to streams maximizes. In another study, average shredder contribution in western Montana reference streams was 8% (Wisseman 1992).
- Percent predators. Macroinvertebrate predators depend on a reliable source of invertebrate prey, and their abundance provides a measure of the trophic complexity supported by a site. Less disturbed sites have more plentiful habitat niches to support diverse prey species, which in turn support abundant predator species.
- Number of "clinger" taxa. So-called "clinger" taxa have physical adaptations that allow them to cling to smooth substrates in rapidly flowing water. Macroinvertebrate "clingers" are sensitive to fine sediments that fill interstices between substrate particles and eliminate habitat complexity. Animals that occupy the hyporheic zones are included in this group of taxa. Expected "clinger" taxa richness in unimpaired streams of western Montana is at least 14 (Bollman, unpublished data).
- Number of long-lived taxa. Long-lived or semivoltine taxa require more than a year to completely develop, and their numbers decline when habitat and/or water quality conditions are unstable. They may completely disappear if channels are

dewatered or if there are periodic water temperature elevations or other interruptions to their life cycles. Western Montana streams with stable habitat conditions are expected to support six or more long-lived taxa (Bollman, unpublished data).

Table 3a. Criteria for the assignment of use-support classifications / standards violation thresholds (from Bukantis, 1997)

% Comparability to reference	Use support
>75	Full support--standards not violated
25-75	Partial support--moderate impairment--standards violated
<25	Non-support--severe impairment--standards violated

Table 3b. Criteria for the assignment of impairment classifications (from Plafkin et al. 1989).

% Comparability to reference	Classification
> 83	nonimpaired
54-79	slightly impaired
21-50	moderately impaired
<17	severely impaired

RESULTS

Habitat assessment

Figure 1 compares habitat assessment results for the seven sites in this study. Tables 4a and 4b itemize the evaluated habitat parameters and show the assigned scores for each.

Figure 1. Habitat assessment scores for seven sites on the Boulder River. August 1999. Sites are described in Table 1. Scores are expressed as percent of maximum.

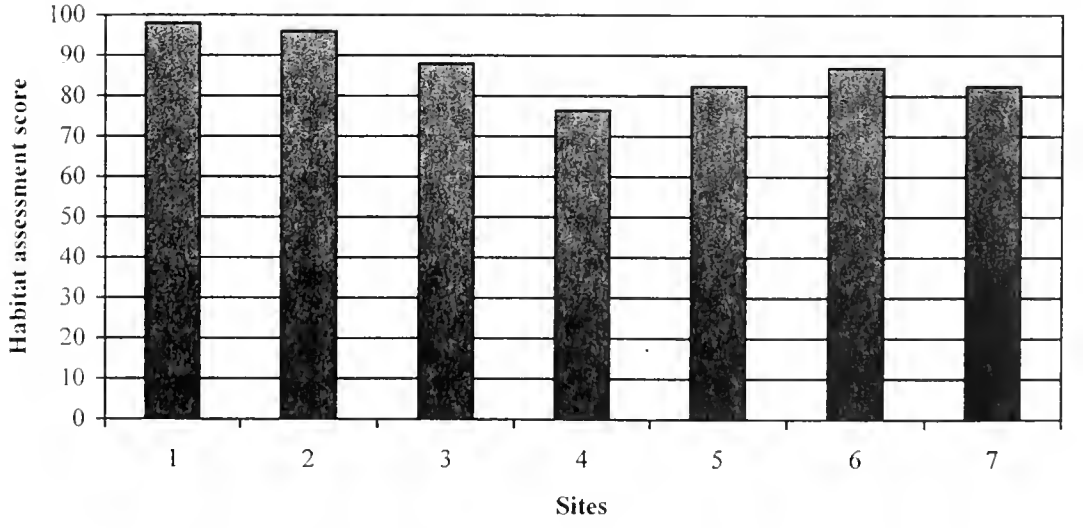


Table 4a. Stream and riparian habitat assessment: Boulder River sites with riffle/run prevalence. August 1999.

Max. possible score	Parameter	Site 1	Site 2	Site 5	Site 6	Site 7
10	**Riffle development**	10	10	10	10	10
10	**Benthic substrate**	10	10	10	7	10
20	**Embeddedness**	18	20	18	20	18
20	**Channel alteration**	20	20	18	18	19
20	**Sediment deposition**	20	18	14	20	16
20	**Channel flow status**	19	18	18	18	12
20	**Bank stability**	10 / 10	10 / 10	8 / 8	10 / 10	9 / 9
20	**Bank vegetation**	10 / 10	10 / 9	7 / 7	7 / 7	8 / 7
20	**Vegetated zone**	10 / 10	10 / 8	7 / 7	6 / 6	7 / 7
160	**Total**	157	153	132	139	132
	Percent of maximum	98	96	82.5	87	82.5
	CONDITION*	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**	**OPTIMAL**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%.
Adapted from Plafkin et al. 1988.

Table 4b. Stream and riparian habitat assessment: Boulder River sites with glide/pool prevalence. August 1999.

Max. possible score	Parameter	Site 3	Site 4
20	**Benthic substrate**	15	18
20	**Pool substrate**	18	18
20	**Pool variability**	20	18
20	**Channel alteration**	20	14
20	**Sediment deposition**	20	18
20	**Channel sinuosity**	10	15
20	**Channel flow status**	20	18
20	**Bank vegetation**	10 / 10	7 / 7
20	**Bank stability**	9 / 9	5 / 5
20	**Vegetated zone**	9 / 6	5 / 5
200	**Total**	176	153
	Percent of maximum	88	76.5
	CONDITION*	**OPTIMAL**	**SUB-OPTIMAL**

* Condition categories: Optimal > 80% of maximum score; Sub-optimal 75 - 56%; Marginal 49 - 29%; Poor <23%.
Adapted from Plafkin et al. 1988.

Generally, habitat conditions on the Boulder River were judged to be optimal, with six of the seven sites scoring near their potential habitat quality. A single site, Site 4, was perceived to have sub-optimal habitat; streambanks appeared to be moderately unstable and the riparian vegetation zone was judged marginal with evidence of grazing impacts.

Mild to moderate accumulations of fine sediment were noted at Sites 5 and 7. Both of these sites were also judged to have sub-optimal streambank vegetative protection, with some evidence of past grazing and a few areas of slumping banks. Site 7, which was the most downstream site studied, was also reported to have sub-optimal flow status; large cobble bars were exposed.

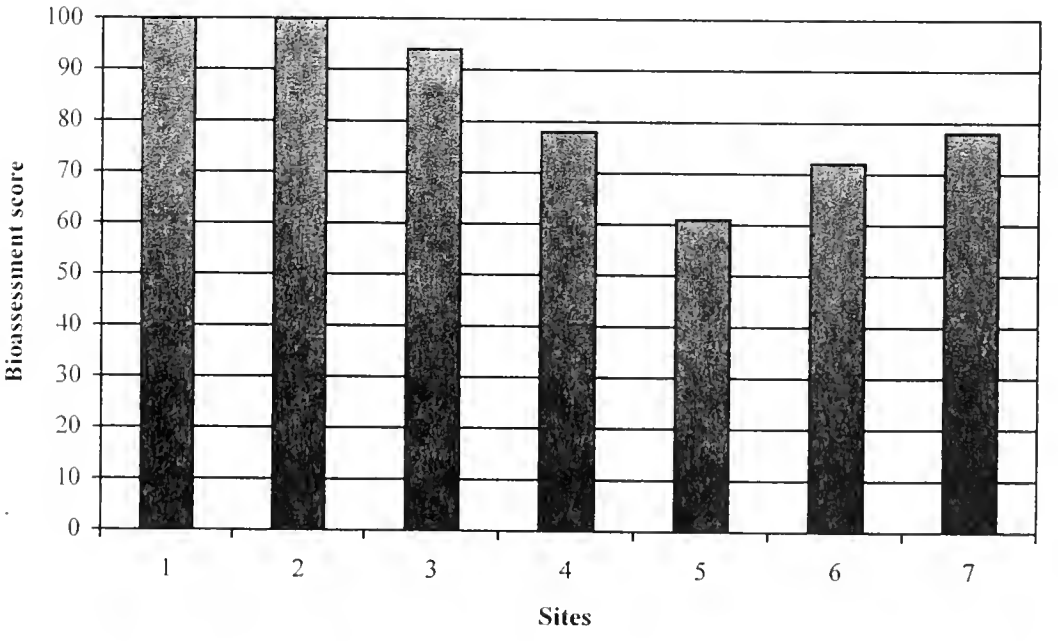
Bank vegetative protection was perceived to be sub-optimal at Site 6, but deposition of fine sediments did not appear to compromise habitat quality at this site. The riparian vegetation zone was judged sub-optimal here.

Bioassessment

Macroinvertebrate taxa lists, metric results and other information for each sample are given in the Appendix.

Figure 2 compares bioassessment scores for macroinvertebrate communities at the seven sites in this study. Table 5 itemizes each contributing metric and shows individual metric scores for each site. Tables 3a and 3b shows criteria for impairment classifications and Montana DEQ recommended use-support categories.

Figure 2. Total bioassessment scores for seven sites on the Boulder River. August 1999. Sites are described in Table 1. Scores are expressed as percent of maximum.



Bioassessment scores for Sites 1, 2, and 3 indicate that in these reaches the Boulder River fully supports designated uses. At Sites 4 and 7, uses are fully supported, but slight impairment of biotic health is indicated. Partial support of designated uses is indicated by scores for Sites 5 and 6; both sites are slightly impaired.

Macroinvertebrate communities

The reaches of the Boulder River represented by samples taken at Sites 1, 2, and 3 support benthic communities typical of unimpaired montane or foothill streams. The low abundance of macroinvertebrates taken at Site 1 (only 211 organisms were present in the entire sample) may have been due to the difficulty inherent in sampling a steep, cascading environment. The smaller number of organisms in the sample may have resulted in the lower than expected taxa richness, and somewhat lower numbers for the richness metrics employed in the bioassessment. The taxonomic composition of the sample suggests, however, that both water and habitat quality were good. Sites 2 and 3 also produced samples with an array of organisms typical of streams with good water quality and intact benthic habitat. An assortment of sensitive taxa were collected at these sites, including the stoneflies *Doroneuria* sp. and *Megarcys* sp., which were present at all three locations, and the caddisfly *Dolophilodes* sp. and mayfly *Drunella doddsi*, both of which were present at sites 2 and 3. These three sites were characterized by low numbers of filter-feeding organisms, which suggests that fine suspended organic material was not abundant; this would be expected in a high-gradient montane or foothill site. Large organic material, such as woody debris from riparian sources was apparently scarce as well, since shredding organisms were not abundant at these sites. Only a few specimens of nemourid stoneflies, *Zapada* spp., were collected at Sites 1 and 2; below these locations, shredders were not present in any other of the Boulder River samples. Habitat assessments suggest that sources of woody debris from riparian areas in the upper reaches of the Boulder River were adequate. Poor retention of woody debris may be characteristic of streams with seasonal scouring flows.

Biotic index scores, ranging from 1.64 at Site 3 to 2.76 at Site 1, indicate good water quality, as does the high mayfly taxa richness at Sites 2 and 3. High numbers of predator taxa suggest a complex trophic structure of the benthic assemblage, this observation, together with the high numbers of Trichoptera taxa and "clinger" taxa indicate well-developed and diverse habitats with little or no impairment by fine sediment deposition.

Downstream of these three sites, the next two sampled reaches show a mildly diminished biotic integrity. The number of sensitive taxa present in samples drops precipitately at Site 4, where only two sensitive taxa were collected. At Site 5, only a single sensitive taxon was present in the sample. The proportion of tolerant organisms in samples begins to increase at Site 4 and remains high in each subsequent downstream sample. The biotic index was higher as well (3.02 at Site 4, 3.60 at Site 5); this could be due to a mild increase in organic and/or nutrient inputs, somewhat warmer water temperatures, or fine sediment deposition. This measurement also increases in each subsequent downstream location. Significantly, the proportion of filter-feeding organisms is higher in these reaches (i.e. Sites 4 and 5) than in any other sampled locations in the river, suggesting that suspended fine organic particles were more abundant here than at other sites. The changes are probably mild at Site 4, but increase at Site 5.

A smaller number of Plecoptera taxa were collected from Sites 4 and 5 than at other sites in the Boulder River, suggesting some alteration or difference in large-scale, reach-level habitat characteristics compared to the other sites studied. Some channel alteration and less-than-expected sinuosity was reported in the habitat assessment made at Site 4, but other factors usually associated with decreased numbers of stonefly taxa, such as widening of channel dimensions or loss of riparian integrity, are not clearly evident. Lower than expected numbers of Trichoptera taxa at Site 4 may indicate mild to moderate deposition of fine sediment.

Site 5 received the lowest bioassessment score of any of the seven sites sampled. A high proportion of tolerant taxa, filter-feeding organisms and midges (41% of the sampled assemblage) suggest that organic and/or nutrient inputs may compromise water quality to some extent in this reach. Although mayfly taxa richness is high, four of the nine taxa collected at this site are in the family Baetidae, which is in general more tolerant to water quality impairments. Site 5 has a relatively low proportion of predatory organisms, suggesting a simplification of the trophic structure of the assemblage at this site. Water quality perturbations are possibly the cause of this disturbance.

No sensitive taxa were present in the sample taken at Site 6. The biotic index calculated at this site was 3.61. The taxonomic composition of the community sampled here suggests that warmer water temperatures and fine sediment deposition contributed to the mild impairment of biologic health at this site. The warm-water tolerant caddisflies *Helicopsyche borealis* and *Oecetis* sp. were present here, as was the sediment tolerant mayfly *Timpanoga hecuba*. Still, predators comprised 12% of the assemblage, and Trichoptera taxa richness was high, suggesting complexity of both trophic structure and habitat.

At the mouth of the Boulder River, Site 7 supported the most tolerant assemblage of any of the sites studied. Warm water and fine sediment were indicated by the presence of *Tricorythodes minutus*, the midges *Dicrotendipes* sp. and *Polypedilum* sp. and by the burrowing mayfly *Paraleptophlebia bicornuta*. The highest biotic index of all sampled sites was calculated for this community (4.38). These findings are probably not remarkable considering that the sample was taken near the mouth of the river. In fact, bioassessment scores indicated full support of designated uses at this site.

CONCLUSIONS

- The three uppermost sites on the Boulder River support benthic assemblages that indicate good water quality and diverse habitats.
- At Site 4, a mild increase in the number of filter-feeders and tolerant organisms suggests that water quality may be slightly impaired by organic and/or nutrient enrichment.
- At Site5 mild impairment of water quality is suggested by increasing numbers of filter-feeding organisms and tolerant animals. There were more midges, as well as higher biotic index values at Site 5. Metric values suggest that impairment may be due to mild organic and/or nutrient inputs.
- Warmer water temperatures and some deposition of fine sediments were suggested by the taxonomic composition of the assemblage at Sites 6 and 7.
- Scarce shredder taxa in all sampled reaches of the Boulder River suggests that retention of woody debris may be compromised in some reaches by seasonal scouring

flows. In other reaches, quantities of in-channel woody debris may be compromised by reduced inputs, due to limitations of the riparian vegetation zone.

- The presence of abundant long-lived taxa indicates that surface flow persists year-round in these sampled reaches of the Boulder River.
- Figure 3 graphically displays the relationship between habitat assessment scores and bioassessment scores for the seven sites on the Boulder River sampled for this study. All but three of the symbols representing sampled sites lie along a line representing the hypothetical relationship between habitat quality and biotic health when habitat degradation is the sole source of impairment to benthic assemblage health. (Barbour and Stribling 1991). The graph suggests that habitat degradation, where present, is mild, and the corresponding impact on biotic integrity is also apparently mild. Sites 5, 6, and 7 lie somewhat below and to the right of this line, suggesting that mild water quality impairment additionally influences biotic health at these sites.

Figure 4. The relationship of habitat assessment scores and bioassessment scores for seven sites on the Boulder River, August 1999. The red curve represents the hypothetical relationship between habitat scores and bioassessment scores if habitat quality solely determined biotic health.

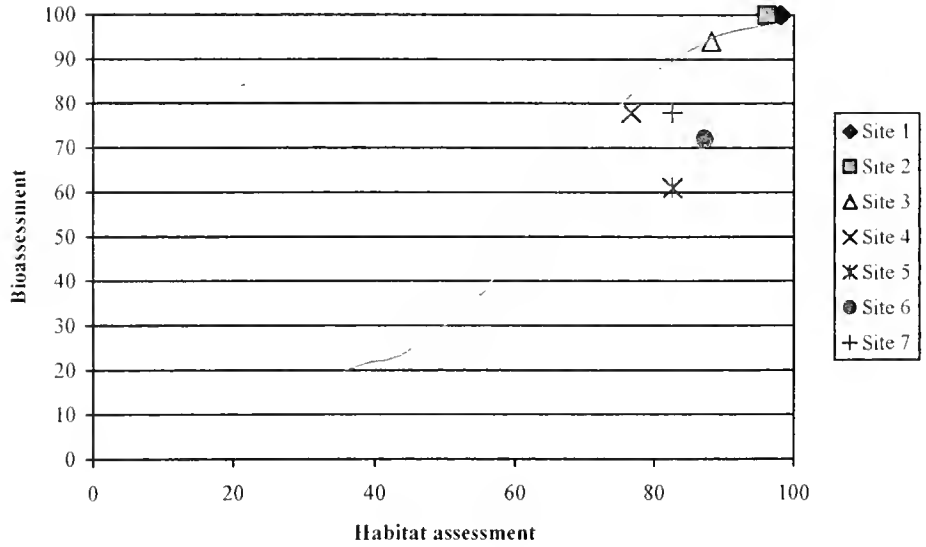


Table 5. Metric values, percentage of reference, and bioassessments for Boulder River sites. August 1999.

metric	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Ephemeroptera richness	6	10	9	10	9	8	6
Plecoptera richness	4	5	3	2	2	3	4
Trichoptera richness	6	6	7	4	5	7	4
Sensitive taxa richness	7	5	5	2	1	0	1
Percent filterers	<1	3	<1	8	11	<1	<1
Percent tolerant taxa	0	<1	3	4	10	8	9
metric score							
Ephemeroptera richness	3	3	3	3	3	3	3
Plecoptera richness	3	3	2	2	2	2	3
Trichoptera richness	3	3	3	2	3	3	2
Sensitive taxa richness	3	3	3	2	1	0	1
Percent filterers	3	3	3	2	1	3	3
Percent tolerant taxa	3	3	3	3	1	2	2
total score (max = 18)	18	18	17	14	11	12	14
% of maximum	100	100	94	78	61	72	78
classification *	NON	NON	NON	SLI	SLI	SLI	SLI
use support †	FULL	FULL	FULL	FULL	PART	PART	FULL

* Classifications: (NON) non-impaired, (SLI) slightly impaired, (MOD) moderately impaired, (SEV) severely impaired. See Table 3b.

† Use support designations: See Table 3a.

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APPENDICES

1. The Montana DEQ metric battery

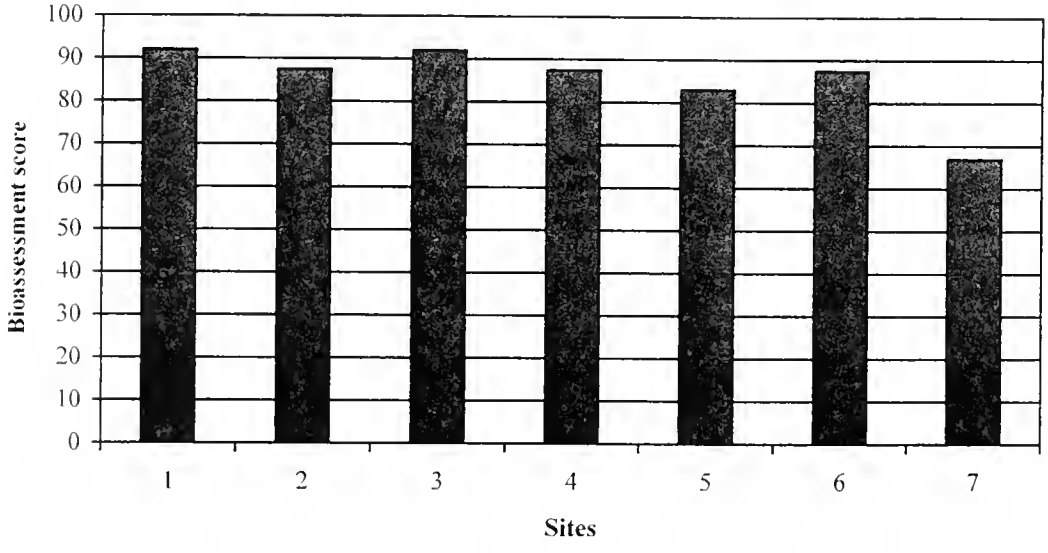
2. Macroinvertebrate taxonomic and metric data

Boulder River, August 1999.

Appendix 1. The Montana DEQ metric battery

Figure A-1 compares bioassessment scores for macroinvertebrate communities at the seven Boulder River sites when the Montana DEQ metric battery is used. Table A-1 itemizes each of the eight contributing metrics and shows individual metric scores for each site. Table A-2 shows the scoring criteria for the Montana DEQ metric battery. When tested for sensitivity to impairment, variability with environmental factors other than anthropogenic impacts and replicability, the Montana DEQ metric battery did not perform as well as the metric battery used in this report (Bollman 1998). These results are furnished to maintain consistency with reports produced previously for Montana DEQ and should be interpreted with caution.

Figure 1-A. Total bioassessment scores, derived using the Montana DEQ metric battery, for seven sites on the Boulder River. August 1999. Sites are described in Table 1. Scores are expressed as percent of maximum.



Full use support is indicated at all sites upstream of Site 7 when the Montana DEQ metric battery and scoring criteria are applied to the macroinvertebrate data from the Boulder River. At Site 7, partial support of designated uses is indicated.

Table A1. Montana Valleys and Foothill Prairies ecoregion reference: metrics and scoring criteria. (From Bukantis 1998).

Metric	Scoring criteria			
	3	2	1	0
Taxa richness	> 28	28 - 21	21 - 14	< 14
EPT richness	> 14	14 - 13	12 - 11	< 11
Biotic index	< 4	4 - 5	5 - 6	6 – 7
Percent dominant taxon	< 30	30 - 40	40 - 50	> 50
Percent collectors (gatherers + filterers)	< 60	60 - 75	75 - 90	> 90
Percent scrapers + shredders	> 30	30 - 20	20 - 10	< 10
Percent Hydropsychinae of Trichoptera	< 75	75 - 85	85 - 95	> 95
Percent EPT	> 60	60 - 45	45 - 30	< 30

Table A-2. Metric values, percentage of reference, and bioassessments for Boulder River sites. Montana DEQ metric battery and scoring criteria for the Montana Valley and Foothill Prairies ecoregion. August 1999

metric	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Taxa richness	22	33	28	31	32	38	28
EPT richness	16	21	19	16	16	18	14
Biotic index	2.76	2.32	1.64	3.02	3.60	3.61	4.38
% dominant taxon	36	38	36	14	15	18	25
% Collector (g+ff)	26	67	20	64	53	40	37
% Scrapers + Shredders	54	29	65	20	12	17	5
% Hydropsychinae of Trich.	0	0	0	9	0	4	<1
% EPT	94	83	86	67	39	50	44
metric score							
Taxa richness	2	3	2	3	3	3	2
EPT richness	3	3	3	3	3	3	2
Biotic index	3	3	3	3	3	3	2
% dominant taxon	2	2	2	3	3	3	3
% Collector (g+ff)	3	2	3	2	3	3	3
% Scrapers + Shredders	3	2	3	1	1	1	0
% Hydropsychinae of Trich.	3	3	3	3	3	3	3
% EPT	3	3	3	3	1	2	1
total score (max = 24)	22	21	22	21	20	21	16
% of maximum	92	87.5	92	87.5	83	87.5	67
use support †	FULL	FULL	FULL	FULL	FULL	FULL	PARTIAL

† Use support designations: See Table 3

Appendix 2. Macroinvertebrate taxonomic and metric data

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River below Basin Creek
Site ID: #1

Taxon	Quantity	Percent	HBI	FFG
Turbellaria	1	0.47	4	CG
Enchytraeidae	5	2.37	10	CG
Total Misc. Taxa	**6**	**2.84**		
Baetis tricaudatus	18	8.53	6	CG
Drunella coloradensis/flavilinea	10	4.74	0	CG
Cinygmula sp.	75	35.55	4	SC
Epeorus albertae	37	17.54	1	SC
Rhithrogena sp.	1	0.47	0	SC
Ameletus sp.	15	7.11	0	CG
Total Ephemeroptera	**156**	**73.93**		
Zapada columbiana	2	0.95	2	SH
Doroneuria sp.	7	3.32	1	PR
Kogotus sp.	2	0.95	2	PR
Megarcys sp.	8	3.79	2	PR
Total Plecoptera	**19**	**9.00**		
Parapsyche elsis	6	2.84	1	PR
Rhyacophila Alberta Gr.	1	0.47	0	PR
Rhyacophila Betteni Gr.	7	3.32	1	PR
Rhyacophila Brunnea Gr.	2	0.95	1	PR
Rhyacophila Hyalinata Gr.	6	2.84	1	PR
Rhyacophial Iranda Gr.	1	0.47	0	PR
Total Trichoptera	**23**	**10.90**		
Prosimulium sp.	2	0.95	3	CF
Total Diptera	**2**	**0.95**		
Cricotopus nostococladius	2	0.95	3	PH
Diamesa sp.	1	0.47	5	CG
Micropsectra sp.	2	0.95	7	CG
Total Chironomidae	**5**	**2.37**		
Grand Total	**211**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River below Basin Creek Site ID: #1

TOTAL ABUNDANCE	211
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	198
TOTAL NUMBER OF TAXA	22
Number EPT taxa	16

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	2	6	2.84
Odonata	0	0	0.00
Ephemeroptera	6	156	73.93
Plecoptera	4	19	9.00
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	6	23	10.90
Lepidoptera	0	0	0.00
Coleoptera	0	0	0.00
Diptera	1	2	0.95
Chrionomidae	3	5	2.37

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	39.60

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	9	40	18.96
Parasite	0	0	0.00
Collector-gatherer	7	52	24.64
Collector-filterer	1	2	0.95
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	2	0.95
Scraper	3	113	53.55
Shredder	1	2	0.95
Xylophage	0	0	0.00
Omnivore	0	0	0.00
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	56.50
Scraper/(Scraper + C.filterer)	0.98
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Cinygmula sp.	75	35.55
Epeorus albertae	37	17.54
Baetis tricaudatus	18	8.53
Ameletus sp.	15	7.11
Drunella coloradensis/flavilinea	10	4.74
SUBTOTAL 5 DOMINANTS	155	73.46
Megarcys sp.	8	3.79
Doroneuria sp.	7	3.32
Rhyacophila Betteni Gr.	7	3.32
Parapsyche elsis	6	2.84
Rhyacophila Hyalinata Gr.	6	2.84
TOTAL DOMINANTS	189	89.57

SAPROBIC INDICES

Hilsenhoff Biotic Index	2.76

DIVERSITY MEASURES

Shannon H (loge)	2.25
Shannon H (log2)	3.24
Evenness	0.73
Simpson D	0.17

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	18	8.65
Univoltine	171	81.16
Semivoltine	22	10.19

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	18	8.53
Intolerant	0	29	13.74
Clinger	13	158	74.88

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River, Upper Aspen Campground
Site ID: #2

Taxon	Quantity	Percent	HBI	FFG
Nematoda	1	0.31	5	PA
Enchytraeidae	1	0.31	10	CG
Total Misc. Taxa	**2**	**0.62**		
Acentrella insignificans	11	3.41	4	CG
Baetis tricaudatus	14	4.33	6	CG
Drunella coloradensis	7	2.17	0	CG
Drunella doddsi	6	1.86	0	CG
Serratella tibialis	124	38.39	2	CG
Cinygmula sp.	12	3.72	4	SC
Epeorus albertae	14	4.33	1	SC
Epeorus longimanus	14	4.33	1	SC
Epeorus grandis	3	0.93	0	SC
Rhithrogena sp.	13	4.02	0	SC
Total Ephemeroptera	**218**	**67.49**		
Suwallia sp.	2	0.62	0	PR
Sweltsa sp.	8	2.48	1	PR
Zapada Oregonensis Gr.	3	0.93	2	SH
Doroneuria sp.	4	1.24	1	PR
Megarcys sp.	4	1.24	2	PR
Total Plecoptera	**21**	**6.50**		
Arctopsyche grandis	3	0.93	1	PR
Micrasema sp.	6	1.86	1	MH
Dolophilodes sp.	5	1.55	2	CF
Rhyacophila Alberta Gr.	1	0.31	0	PR
Rhyacophila Angelita Gr.	6	1.86	0	PR
Rhyacophila Brunnea Gr.	9	2.79	1	PR
Total Trichoptera	**30**	**9.29**		
Heterlimnius sp.	6	1.86	4	CG
Optioservus sp.	3	0.93	4	SC
Total Coleoptera	**9**	**2.79**		
Simulium sp.	6	1.86	6	CF
Total Diptera	**6**	**1.86**		
Cricotopus (Isocladius)	1	0.31	7	CG
Diamesa sp.	3	0.93	5	CG
Eukiefferiella Devonica Gr.	2	0.62	4	OM
Micropsectra sp.	3	0.93	7	CG
Orthocladius sp.	4	1.24	6	CG
Pagastia sp.	10	3.10	1	CG
Tvetenia sp.	14	4.33	5	CG
Total Chironomidae	**37**	**11.46**		
Grand Total	**323**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River, Upper Aspen Cam Site ID: #2

TOTAL ABUNDANCE	323
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	269
TOTAL NUMBER OF TAXA	33
Number EPT taxa	21

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	2	2	0.62
Odonata	0	0	0.00
Ephemeroptera	10	218	67.49
Plecoptera	5	21	6.50
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	6	30	9.29
Lepidoptera	0	0	0.00
Coleoptera	2	9	2.79
Diptera	1	6	1.86
Chrionomidae	7	37	11.46

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	7.27

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	8	37	11.46
Parasite	1	1	0.31
Collector-gatherer	13	204	63.16
Collector-filterer	2	11	3.41
Macrophyte-herbivore	1	6	1.86
Piercer-herbivore	0	0	0.00
Scraper	6	59	18.27
Shredder	1	3	0.93
Xylophage	0	0	0.00
Omnivore	1	2	0.62
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	5.36
Scraper/(Scraper + C.filterer)	0.84
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Serratella tibialis	124	38.39
Baetis tricaudatus	14	4.33
Epeorus albertae	14	4.33
Epeorus longimanus	14	4.33
Tvetenia sp.	14	4.33
SUBTOTAL 5 DOMINANTS	180	55.73
Rhithrogena sp.	13	4.02
Cinygmula sp.	12	3.72
Acentrella insignificans	11	3.41
Pagastia sp.	10	3.10
Rhyacophila Brunnea Gr.	9	2.79
TOTAL DOMINANTS	235	72.76

SAPROBIC INDICES

Hilsenhoff Biotic Index	2.32

DIVERSITY MEASURES

Shannon H (loge)	2.29
Shannon H (log2)	3.31
Evenness	0.66
Simpson D	0.14

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	48	14.71
Univoltine	252	77.86
Semivoltine	24	7.43

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	17	5.26
Intolerant	5	23	7.12
Clinger	19	243	75.23

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River, Aller Ranch
Site ID: #3

Taxon	Quantity	Percent	HBI	FFG
Acentrella insignificans	1	0.30	4	CG
Baetis tricaudatus	4	1.22	6	CG
Drunella doddsi	16	4.88	0	CG
Drunella grandis	7	2.13	2	CG
Serratella tibialis	19	5.79	2	CG
Cinygmula sp.	15	4.57	4	SC
Epeorus albertae	42	12.80	1	SC
Epeorus longimanus	10	3.05	1	SC
Rhithrogena sp.	17	5.18	0	SC
Total Ephemeroptera	**131**	**39.94**		
Doroneuria sp.	3	0.91	1	PR
Hesperoperla pacifica	14	4.27	2	PR
Megarcys sp.	6	1.83	2	PR
Total Plecoptera	**23**	**7.01**		
Arctopsyche grandis	2	0.61	1	PR
Brachycentrus americanus	1	0.30	1	OM
Micrasema sp.	1	0.30	1	MH
Glossosoma sp.	119	36.28	1	SC
Dolophilodes sp.	2	0.61	2	CF
Rhyacophila Angelita Gr.	1	0.30	0	PR
Rhyacophila Brunnea Gr.	3	0.91	1	PR
Total Trichoptera	**129**	**39.33**		
Heterlimnius sp.	7	2.13	4	CG
Optioservus sp.	9	2.74	4	SC
Total Coleoptera	**16**	**4.88**		
Atherix sp.	7	2.13	4	PR
Hexatoma sp.	10	3.05	2	PR
Total Diptera	**17**	**5.18**		
Eukiefferiella Devonica Gr.	2	0.61	4	OM
Micropsectra sp.	3	0.91	7	CG
Orthocladius sp.	2	0.61	6	CG
Pagastia sp.	1	0.30	1	CG
Tvetenia sp.	4	1.22	5	CG
Total Chironomidae	**12**	**3.66**		
Grand Total	**328**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River, Aller Ranch **Site ID: #3**

TOTAL ABUNDANCE	328
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	283
TOTAL NUMBER OF TAXA	28
Number EPT taxa	19

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	0	0	0.00
Odonata	0	0	0.00
Ephemeroptera	9	131	39.94
Plecoptera	3	23	7.01
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	7	129	39.33
Lepidoptera	0	0	0.00
Coleoptera	2	16	4.88
Diptera	2	17	5.18
Chrionomidae	5	12	3.66

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	23.58

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	8	46	14.02
Parasite	0	0	0.00
Collector-gatherer	10	64	19.51
Collector-filterer	1	2	0.61
Macrophyte-herbivore	1	1	0.30
Piercer-herbivore	0	0	0.00
Scraper	6	212	64.63
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	2	3	0.91
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	106.00
Scraper/(Scraper + C.filterer)	0.99
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Glossosoma sp.	119	36.28
Epeorus albertae	42	12.80
Serratella tibialis	19	5.79
Rhithrogena sp.	17	5.18
Drunella doddsi	16	4.88
SUBTOTAL 5 DOMINANTS	213	64.94
Cinygmula sp.	15	4.57
Hesperoperla pacifica	14	4.27
Epeorus longimanus	10	3.05
Hexatoma sp.	10	3.05
Optioservus sp.	9	2.74
TOTAL DOMINANTS	271	82.62

SAPROBIC INDICES

Hilsenhoff Biotic Index	1.64

DIVERSITY MEASURES

Shannon H (loge)	2.45
Shannon H (log2)	3.54
Evenness	0.74
Simpson D	0.16

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	13	3.89
Univoltine	277	84.53
Semivoltine	38	11.59

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	20	6.10
Intolerant	4	27	8.23
Clinger	17	277	84.45

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River, Hass ranch
Site ID: #4

Taxon	Quantity	Percent	HBI	FFG
Acari	1	0.31	5	PA
Total Misc. Taxa	**1**	**0.31**		
Acentrella insignificans	21	6.44	4	CG
Baetis flavistriga	6	1.84	5	CG
Baetis tricaudatus	24	7.36	6	CG
Drunella doddsi	30	9.20	0	CG
Drunella grandis	16	4.91	2	CG
Ephemerella inermis/infrequens	1	0.31	1	CG
Serratella tibialis	47	14.42	2	CG
Cinygmula sp.	1	0.31	4	SC
Epeorus albertae	3	0.92	1	SC
Rhithrogena sp.	37	11.35	0	SC
Total Ephemeroptera	**186**	**57.06**		
Hesperoperla pacifica	1	0.31	2	PR
Pteronarcys sp.	1	0.31	0	OM
Total Plecoptera	**2**	**0.61**		
Arctopsyche grandis	8	2.45	1	PR
Brachycentrus americanus	12	3.68	1	OM
Glossosoma sp.	9	2.76	1	SC
Hydropsyche sp.	3	0.92	4	CF
Total Trichoptera	**32**	**9.82**		
Optioservus sp.	14	4.29	4	SC
Total Coleoptera	**14**	**4.29**		
Atherix sp.	21	6.44	4	PR
Chelifera sp.	1	0.31	6	PR
Simulium sp.	22	6.75	6	CF
Hexatoma sp.	2	0.61	2	PR
Total Diptera	**46**	**14.11**		
Cricotopus (Isocladius)	3	0.92	7	CG
Cricotopus Trifascia Gr.	11	3.37	6	CG
Diamesa sp.	1	0.31	5	CG
Eukiefferiella Devonica Gr.	3	0.92	4	OM
Eukiefferiella Pseudomontana Gr.	2	0.61	8	OM
Micropsectra sp.	13	3.99	7	CG
Orthocladius sp.	3	0.92	6	CG
Pagastia sp.	3	0.92	1	CG
Tvetenia sp.	6	1.84	5	CG
Total Chironomidae	**45**	**13.80**		
Grand Total	**326**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River, Hass ranch **Site ID: #4**

TOTAL ABUNDANCE	326
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	220
TOTAL NUMBER OF TAXA	31
Number EPT taxa	16

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	1	1	0.31
Odonata	0	0	0.00
Ephemeroptera	10	186	57.06
Plecoptera	2	2	0.61
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	4	32	9.82
Lepidoptera	0	0	0.00
Coleoptera	1	14	4.29
Diptera	4	46	14.11
Chrionomidae	9	45	13.80

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	4.89

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	33	10.12
Parasite	1	1	0.31
Collector-gatherer	14	185	56.75
Collector-filterer	2	25	7.67
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	5	64	19.63
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	4	18	5.52
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	2.56
Scraper/(Scraper + C.filterer)	0.72
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Serratella tibialis	47	14.42
Rhithrogena sp.	37	11.35
Drunella doddsi	30	9.20
Baetis tricaudatus	24	7.36
Simulium sp.	22	6.75
SUBTOTAL 5 DOMINANTS	160	49.08
Acentrella insignificans	21	6.44
Atherix sp.	21	6.44
Drunella grandis	16	4.91
Optioservus sp.	14	4.29
Micropsectra sp.	13	3.99
TOTAL DOMINANTS	245	75.15

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.02

DIVERSITY MEASURES

Shannon H (loge)	2.54
Shannon H (log2)	3.67
Evenness	0.74
Simpson D	0.07

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	74	22.62
Univoltine	216	66.33
Semivoltine	36	11.04

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	61	18.71
Intolerant	1	30	9.20
Clinger	16	218	66.87

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River below East Boulder confluence
Site ID: #5

Taxon	Quantity	Percent	HBI	FFG
Nais variabilis	3	0.93	8	CG
Total Misc. Taxa	**3**	**0.93**		
Acentrella insignificans	20	6.21	4	CG
Baetis flavistriga	4	1.24	5	CG
Baetis tricaudatus	5	1.55	6	CG
Diphetor hageni	1	0.31	5	CG
Drunella grandis	3	0.93	2	CG
Ephemerella inermis/infrequens	5	1.55	1	CG
Serratella tibialis	10	3.11	2	CG
Cinygmula sp.	3	0.93	4	SC
Epeorus longimanus	2	0.62	1	SC
Total Ephemeroptera	**53**	**16.46**		
Perlodidae-early instar	2	0.62	2	PR
Pteronarcys californica	1	0.31	1	OM
Total Plecoptera	**3**	**0.93**		
Arctopsyche grandis	3	0.93	1	PR
Brachycentrus americanus	49	15.22	1	OM
Brachycentrus occidentalis	11	3.42	1	OM
Glossosoma sp.	5	1.55	1	SC
Ochrotrichia sp.	2	0.62	4	PH
Total Trichoptera	**70**	**21.74**		
Heterlimnius sp.	2	0.62	4	CG
Optioservus sp.	28	8.70	4	SC
Total Coleoptera	**30**	**9.32**		
Atherix sp.	10	3.11	4	PR
Simulium sp.	16	4.97	6	CF
Dicranota sp.	2	0.62	3	PR
Hexatoma sp.	4	1.24	2	PR
Total Diptera	**32**	**9.94**		
Cricotopus (Isocladius)	21	6.52	7	CG
Eukiefferiella Devonica Gr.	28	8.70	4	OM
Micropsectra sp.	17	5.28	7	CG
Orthocladius sp.	9	2.80	6	CG
Pagastia sp.	31	9.63	1	CG
Polypedilum sp.	1	0.31	6	OM
Potthastia sp.	1	0.31	2	CG
Tanytarsus sp.	18	5.59	6	CF
Tvetenia sp.	5	1.55	5	CG
Total Chironomidae	**131**	**40.68**		
Grand Total	**322**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River below East Boulder Site ID: #5

TOTAL ABUNDANCE	322
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	126
TOTAL NUMBER OF TAXA	32
Number EPT taxa	16

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	1	3	0.93
Odonata	0	0	0.00
Ephemeroptera	9	53	16.46
Plecoptera	2	3	0.93
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	5	70	21.74
Lepidoptera	0	0	0.00
Coleoptera	2	30	9.32
Diptera	4	32	9.94
Chrionomidae	9	131	40.68

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	0.96

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	5	21	6.52
Parasite	0	0	0.00
Collector-gatherer	15	137	42.55
Collector-filterer	2	34	10.56
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	2	0.62
Scraper	4	38	11.80
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	5	90	27.95
Unknown	0	0	0.00

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	1.12
Scraper/(Scraper + C.filterer)	0.53
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Brachycentrus americanus	49	15.22
Pagastia sp.	31	9.63
Optioservus sp.	28	8.70
Eukiefferiella Devonica Gr.	28	8.70
Cricotopus (Isocladius)	21	6.52
SUBTOTAL 5 DOMINANTS	157	48.76
Acentrella insignificans	20	6.21
Tanytarsus sp.	18	5.59
Micropsectra sp.	17	5.28
Simulium sp.	16	4.97
Brachycentrus occidentalis	11	3.42
TOTAL DOMINANTS	239	74.22

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.60

DIVERSITY MEASURES

Shannon H (loge)	2.60
Shannon H (log2)	3.75
Evenness	0.75
Simpson D	0.07

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	122	37.97
Univoltine	106	32.84
Semivoltine	94	29.19

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	45	13.98
Intolerant	0	0	0.00
Clinger	17	180	55.90

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River, McGuane ranch
Site ID: #6

Taxon	Quantity	Percent	HBI	FFG
Enchytraeidae	1	0.33	10	CG
Nais variabilis	1	0.33	8	CG
Physella sp.	2	0.65	8	CG
Acari	3	0.98	5	PA
Total Misc. Taxa	7	**2.28**		
Acentrella insignificans	2	0.65	4	CG
Baetis tricaudatus	1	0.33	6	CG
Diphetor hageni	1	0.33	5	CG
Ephemerella inermis/infrequens	54	17.59	1	CG
Timpanoga hecuba	8	2.61	7	CG
Epeorus albertae	14	4.56	1	SC
Nixe sp.	8	2.61	2	SC
Paraleptophlebia bicornuta	3	0.98	4	CG
Total Ephemeroptera	**91**	**29.64**		
Sweltsa sp.	4	1.30	1	PR
Claassenia sabulosa	2	0.65	3	PR
Hesperoperla pacifica	1	0.33	2	PR
Total Plecoptera	**7**	**2.28**		
Arctopsyche grandis	13	4.23	1	PR
Brachycentrus americanus	3	0.98	1	OM
Brachycentrus occidentalis	31	10.10	1	OM
Glossosoma sp.	5	1.63	1	SC
Helicopsyche borealis	1	0.33	7	SC
Hydropsyche sp.	2	0.65	4	CF
Oecetis sp.	1	0.33	8	OM
Total Trichoptera	**56**	**18.24**		
Dytiscidae	8	2.61	5	PR
Heterlimnius sp.	1	0.33	4	CG
Optioservus sp.	20	6.51	4	SC
Total Coleoptera	**29**	**9.45**		
Atherix sp.	5	1.63	4	PR
Antocha sp.	3	0.98	3	CG
Hexatoma sp.	4	1.30	2	PR
Total Diptera	**12**	**3.91**		
Cricotopus (Isocladius)	27	8.79	7	CG
Diamesa sp.	1	0.33	5	CG
Micropsectra sp.	5	1.63	7	CG
Orthocladius sp.	6	1.95	6	CG
Pagastia sp.	3	0.98	1	CG
Parametriocnemus sp.	1	0.33	5	CG
Phaenopsectra sp.	4	1.30	7	SC
Polypedilum sp.	55	17.92	6	OM
Potthastia sp.	1	0.33	2	CG
Sublettea sp.	2	0.65	4	UN
Total Chironomidae	**105**	**34.20**		
Grand Total	**307**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River, McGuane ranch Site ID: #6

TOTAL ABUNDANCE	307
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	154
TOTAL NUMBER OF TAXA	38
Number EPT taxa	18

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	4	7	2.28
Odonata	0	0	0.00
Ephemeroptera	8	91	29.64
Plecoptera	3	7	2.28
Hemiptera	0	0	0.00
Megaloptera	0	0	0.00
Trichoptera	7	56	18.24
Lepidoptera	0	0	0.00
Coleoptera	3	29	9.45
Diptera	3	12	3.91
Chrionomidae	10	105	34.20

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.47

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	7	37	12.05
Parasite	1	3	0.98
Collector-gatherer	18	121	39.41
Collector-filterer	1	2	0.65
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	0	0	0.00
Scraper	6	52	16.94
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	4	90	29.32
Unknown	1	2	0.65

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	26.00
Scraper/(Scraper + C.filterer)	0.96
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Polypedilum sp.	55	17.92
Ephemerella inermis/infrequens	54	17.59
Brachycentrus occidentalis	31	10.10
Cricotopus (Isocladius)	27	8.79
Optioservus sp.	20	6.51
SUBTOTAL 5 DOMINANTS	187	60.91
Epeorus albertae	14	4.56
Arctopsyche grandis	13	4.23
Timpanoga hecuba	8	2.61
Nixe sp.	8	2.61
Dytiscidae	8	2.61
TOTAL DOMINANTS	238	77.52

SAPROBIC INDICES

Hilsenhoff Biotic Index	3.61

DIVERSITY MEASURES

Shannon H (loge)	2.48
Shannon H (log2)	3.58
Evenness	0.68
Simpson D	0.08

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	85	27.77
Univoltine	143	46.50
Semivoltine	79	25.73

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	41	13.36
Intolerant	0	0	0.00
Clinger	15	245	79.80

Aquatic Macroinvertebrate Taxonomic Data

Site Name: Boulder River, mouth
Site ID: #7

Taxon	Quantity	Percent	HBI	FFG
Nais bretscheri	1	0.31	8	CG
Nais variabilis	10	3.13	8	CG
Acari	1	0.31	5	PA
Total Misc. Taxa	**12**	**3.75**		
Acentrella insignificans	19	5.94	4	CG
Baetis tricaudatus	1	0.31	6	CG
Ephemerella inermis/infrequens	30	9.38	1	CG
Nixe sp.	7	2.19	2	SC
Paraleptophlebia bicornuta	2	0.63	4	CG
Tricorythodes minutus	7	2.19	4	CG
Total Ephemeroptera	**66**	**20.63**		
Doroneuria sp.	4	1.25	1	PR
Hesperoperla pacifica	1	0.31	2	PR
Skwala sp.	1	0.31	2	PR
Pteronarcella sp.	1	0.31	0	OM
Total Plecoptera	**7**	**2.19**		
Corixidae	26	8.13	8	UN
Total Hemiptera	**26**	**8.13**		
Brachycentrus occidentalis	65	20.31	1	OM
Glossosoma sp.	1	0.31	1	SC
Hydropsyche sp.	1	0.31	4	CF
Hydroptila sp.	1	0.31	6	PH
Total Trichoptera	**68**	**21.25**		
Heterlimnius sp.	1	0.31	4	CG
Optioservus sp.	9	2.81	4	SC
Total Coleoptera	**10**	**3.13**		
Antocha sp.	1	0.31	3	CG
Hexatoma sp.	2	0.63	2	PR
Total Diptera	**3**	**0.94**		
Cricotopus (Isocladius)	31	9.69	7	CG
Dicrotendipes sp.	1	0.31	8	CG
Micropsectra sp.	13	4.06	7	CG
Pagastia sp.	1	0.31	1	CG
Polypedilum sp.	81	25.31	6	OM
Sublettea sp.	1	0.31	4	UN
Total Chironomidae	**128**	**40.00**		
Grand Total	**320**	**100.00**		

Aquatic Macroinvertebrate Summary Data

Site Name: Boulder River, mouth **Site ID: #7**

TOTAL ABUNDANCE	320
Ephemeroptera + Plecoptera + Trichoptera (EPT) abundance	141
TOTAL NUMBER OF TAXA	28
Number EPT taxa	14

TAXONOMIC GROUP COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Misc. Taxa	3	12	3.75
Odonata	0	0	0.00
Ephemeroptera	6	66	20.63
Plecoptera	4	7	2.19
Hemiptera	1	26	8.13
Megaloptera	0	0	0.00
Trichoptera	4	68	21.25
Lepidoptera	0	0	0.00
Coleoptera	2	10	3.13
Diptera	2	3	0.94
Chrionomidae	6	128	40.00

RATIOS OF TAX GROUP ABUNDANCES

EPT/Chironomidae	1.10

FUNCTIONAL FEEDING GROUP (FFG) COMPOSITION

GROUP	#TAXA	ABUNDAN	PERCENT
Predator	4	8	2.50
Parasite	1	1	0.31
Collector-gatherer	13	118	36.88
Collector-filterer	1	1	0.31
Macrophyte-herbivore	0	0	0.00
Piercer-herbivore	1	1	0.31
Scraper	3	17	5.31
Shredder	0	0	0.00
Xylophage	0	0	0.00
Omnivore	3	147	45.94
Unknown	2	27	8.44

RATIOS OF FFG ABUNDANCES

Scraper/Collector-filterer	17.00
Scraper/(Scraper + C.filterer)	0.94
Shredder/Total organisms	0.00

CONTRIBUTION OF DOMINANT TAXA

TAXON	ABUNDANCE	PERCENT
Polypedilum sp.	81	25.31
Brachycentrus occidentalis	65	20.31
Cricotopus (Isocladius)	31	9.69
Ephemerella inermis/infrequens	30	9.38
Corixidae	26	8.13
SUBTOTAL 5 DOMINANTS	233	72.81
Acentrella insignificans	19	5.94
Micropsectra sp.	13	4.06
Nais variabilis	10	3.13
Optioservus sp.	9	2.81
Nixe sp.	7	2.19
TOTAL DOMINANTS	291	90.94

SAPROBIC INDICES

Hilsenhoff Biotic Index	4.38

DIVERSITY MEASURES

Shannon H (loge)	2.01
Shannon H (log2)	2.89
Evenness	0.60
Simpson D	0.12

COMMUNITY VOLTINISM ANALYSIS

TYPE	ABUNDANCE	PERCENT
Multivoltine	113	35.31
Univoltine	126	39.38
Semivoltine	81	25.31

	#TAXA	ABUNDANCE	PERCENT
Tolerant	12	21	6.56
Intolerant	1	4	1.25
Clinger	12	299	93.44